



US005944087A

United States Patent [19]

Sterett

[11] Patent Number: **5,944,087**

[45] Date of Patent: **Aug. 31, 1999**

[54] **PROCESS FOR PRODUCING THE MOLD INSERTS FOR INJECTION MOLDINGS**

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[21] Appl. No.: **09/032,193**

[22] Filed: **Feb. 27, 1998**

Related U.S. Application Data

[62] Division of application No. 08/607,755, Feb. 27, 1996, Pat. No. 5,744,173.

[51] Int. Cl.⁶ **B22D 23/00; B22D 33/04**

[52] U.S. Cl. **164/130; 164/137**

[58] Field of Search 146/137, 129, 146/130

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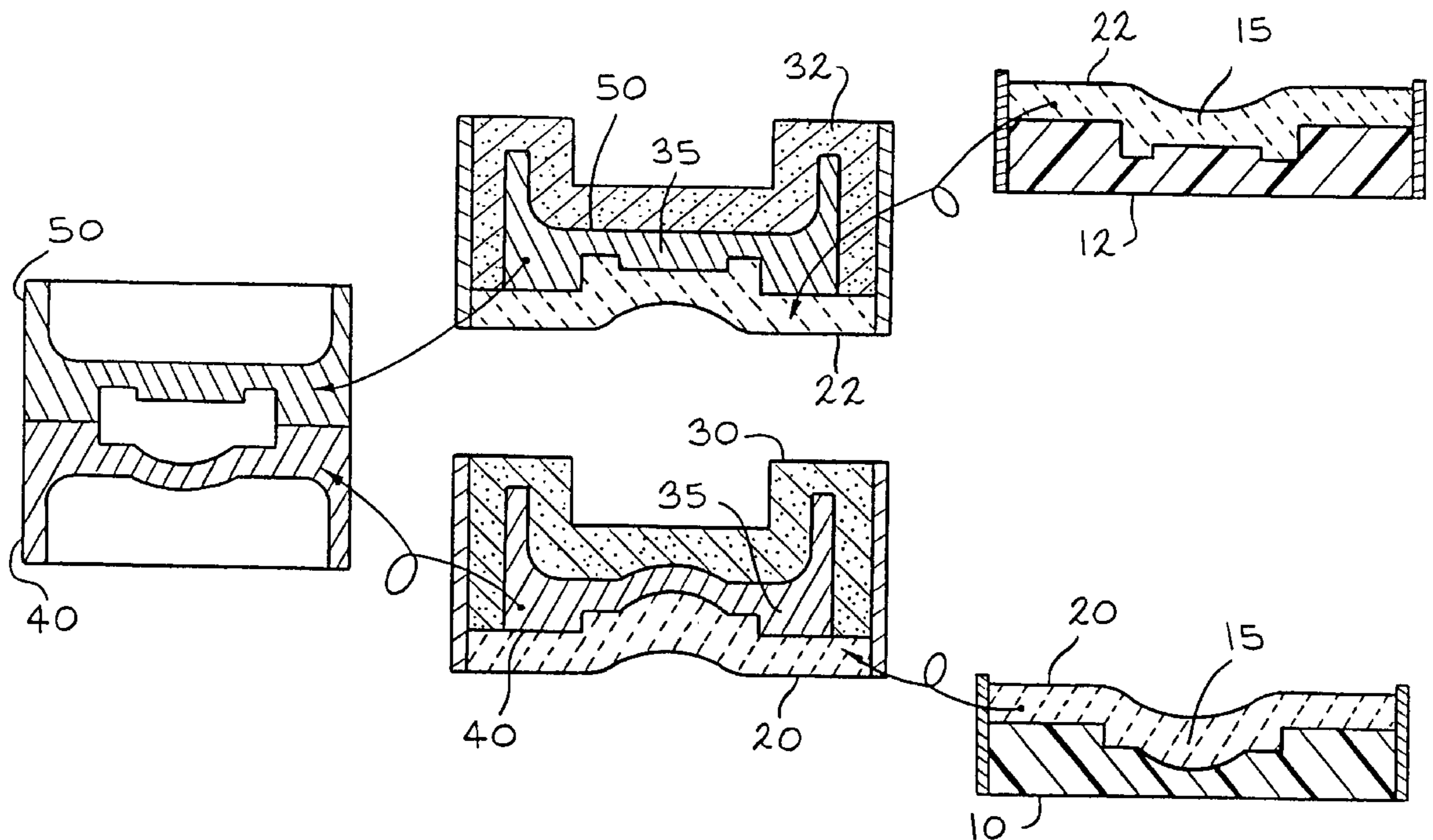
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[57] ABSTRACT

The present relates to an method to produce a molding apparatus for molding plastic parts which comprises a cavity insert and a core insert wherein each insert has an open area on the shell or back side thereof. A device for circulating fluid through each chamber cools the inserts. In one preferred embodiment, the cavity and core inserts are made using a mold having a ceramic formulation including generally uniform size aggregate materials and carbon fibers. In certain embodiments, the apparatus further includes pressure bearing devices, for absorbing molding pressure during operation of the molding apparatus.

19 Claims, 5 Drawing Sheets



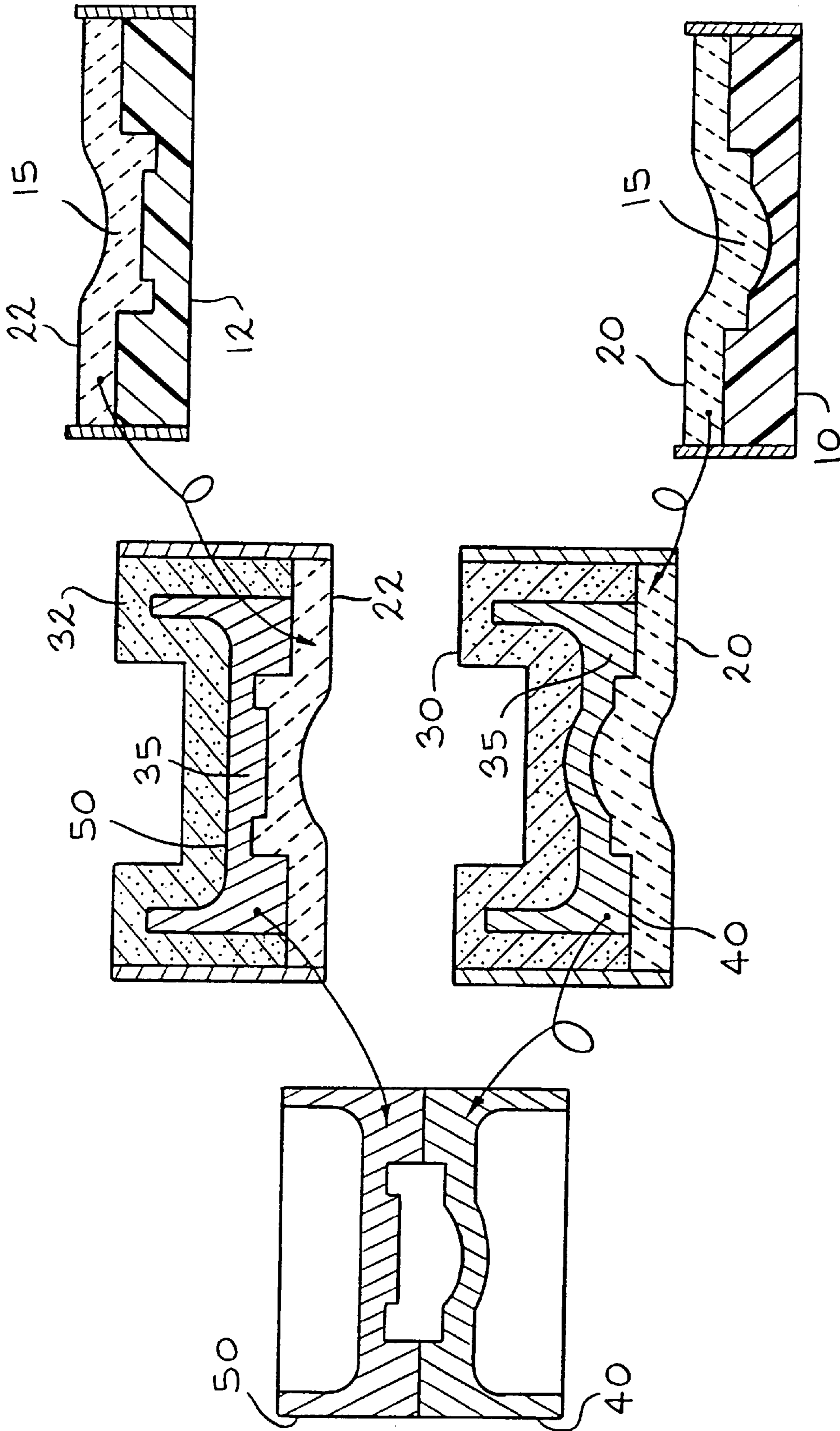


FIG. 2

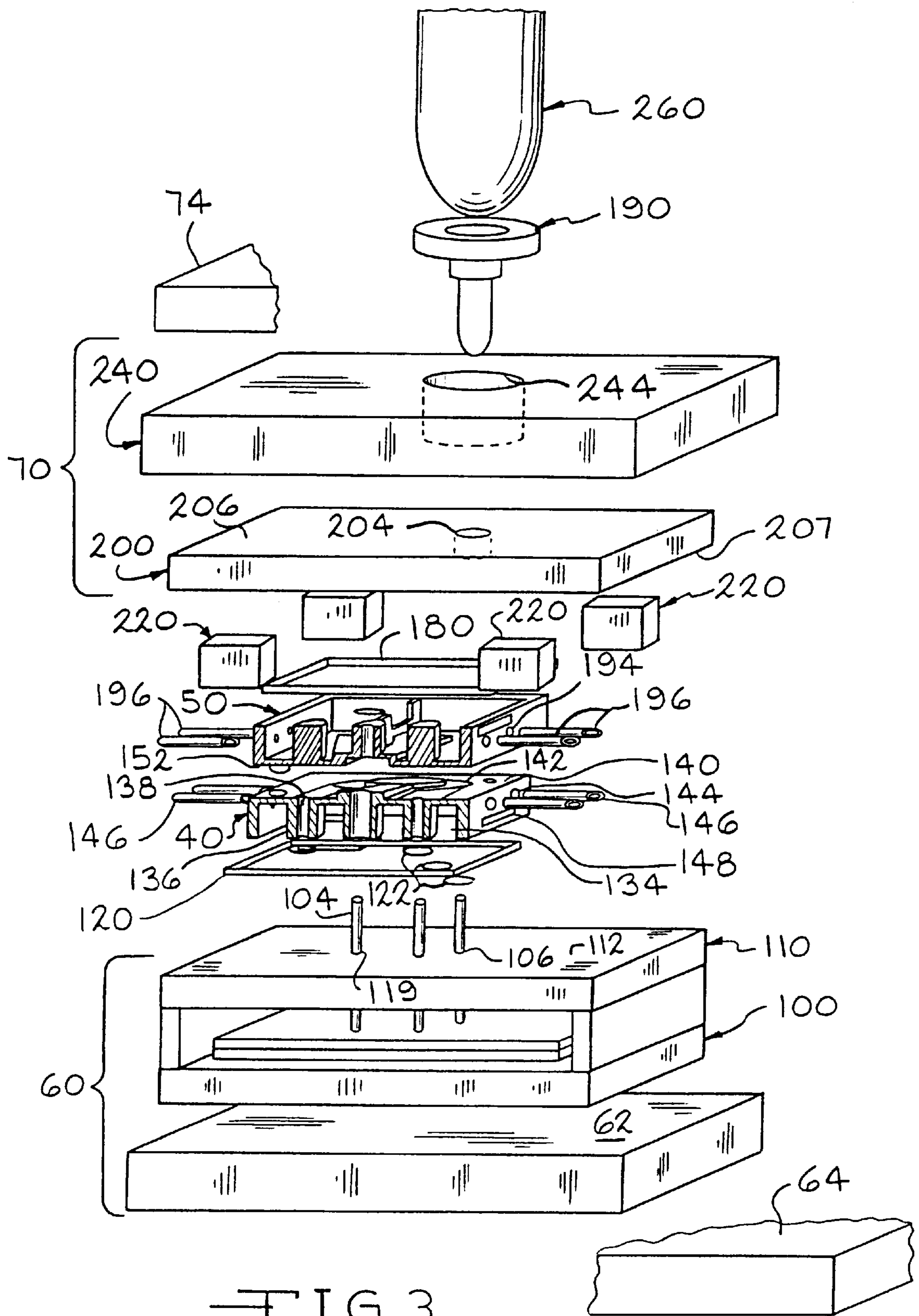


FIG. 3

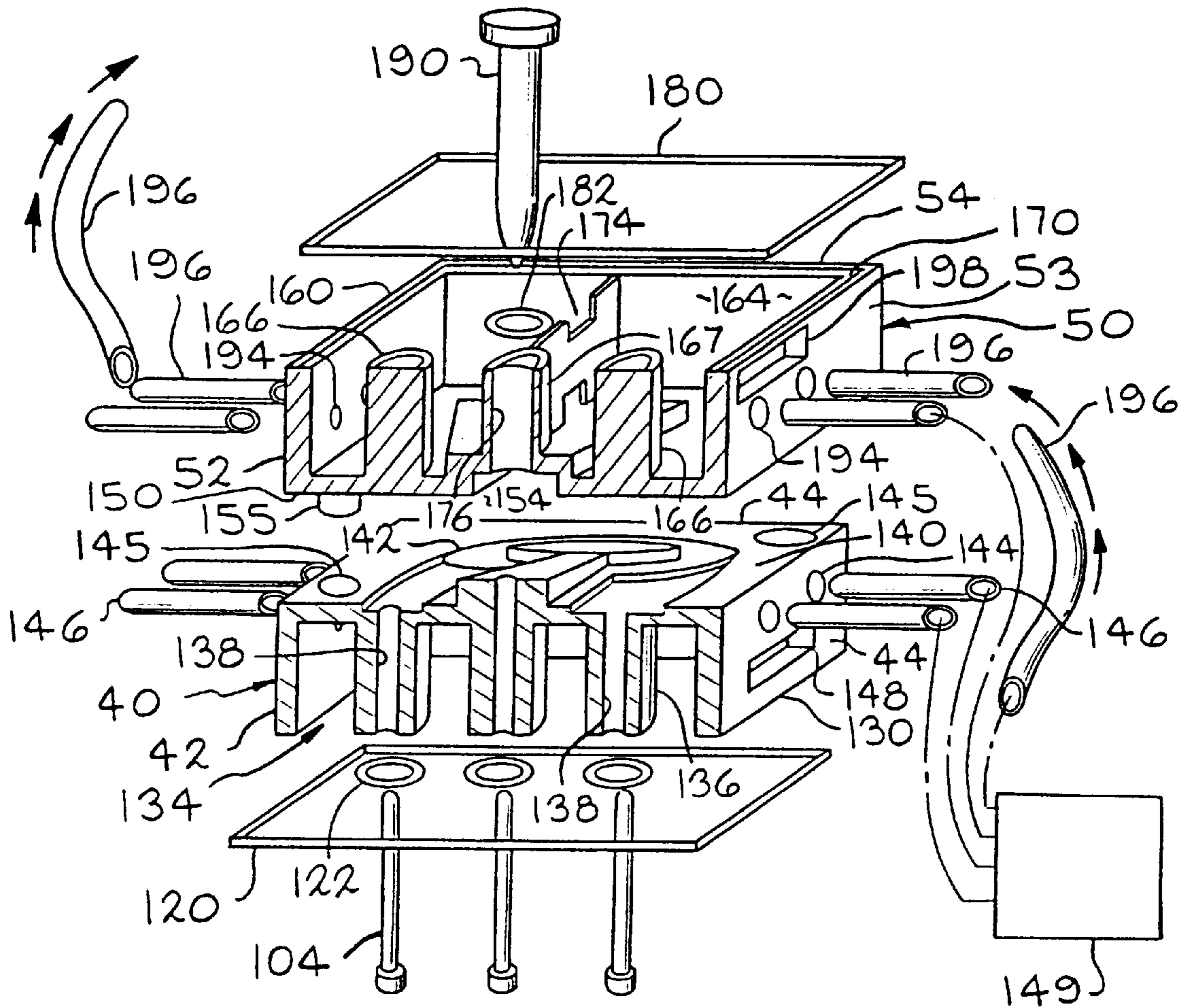
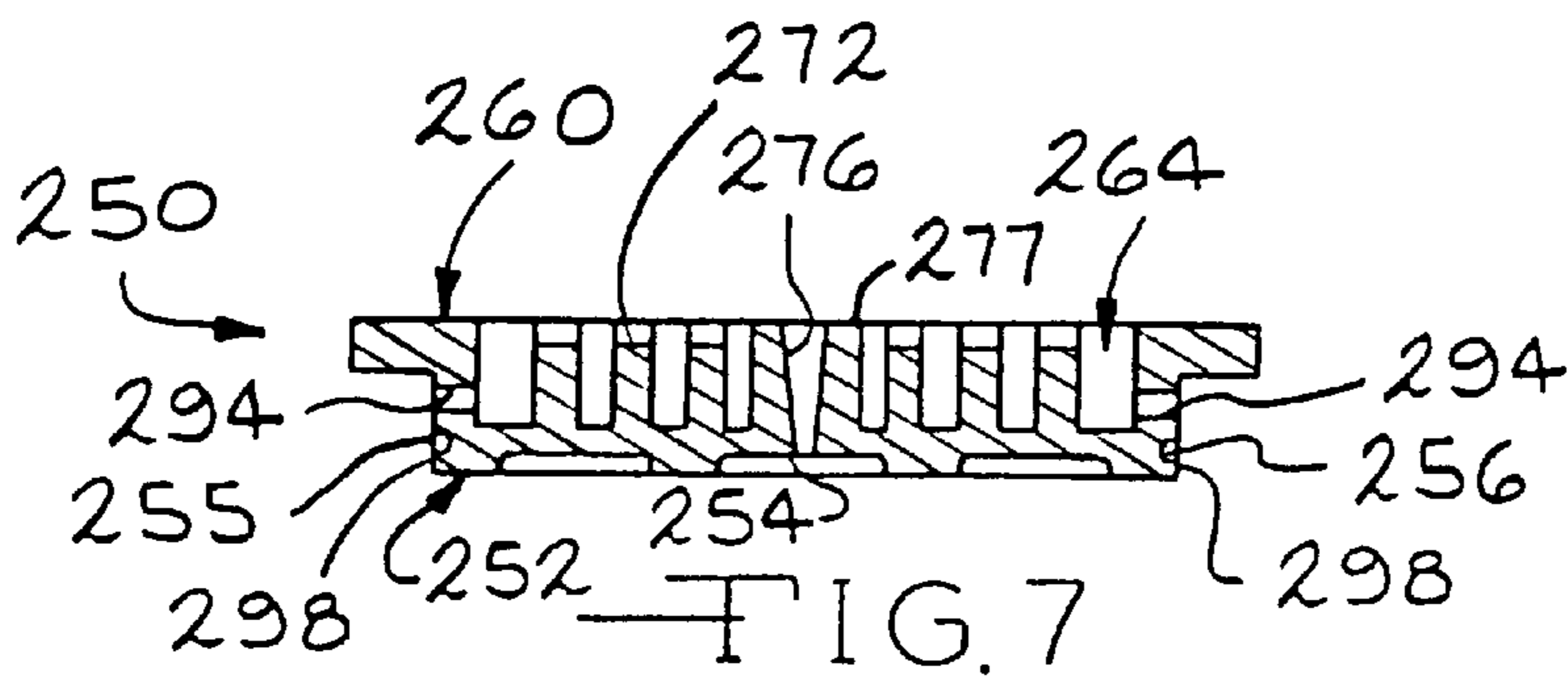
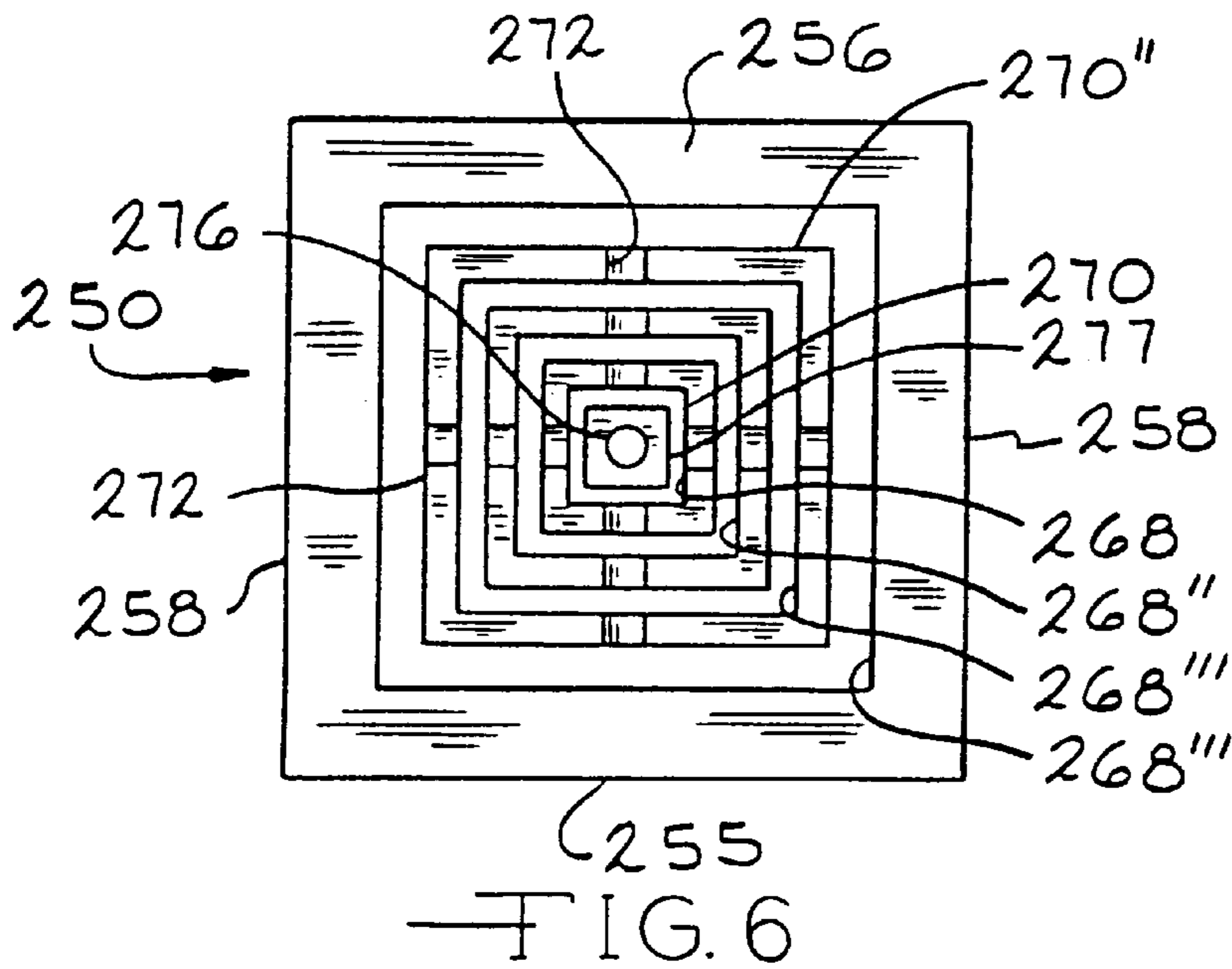
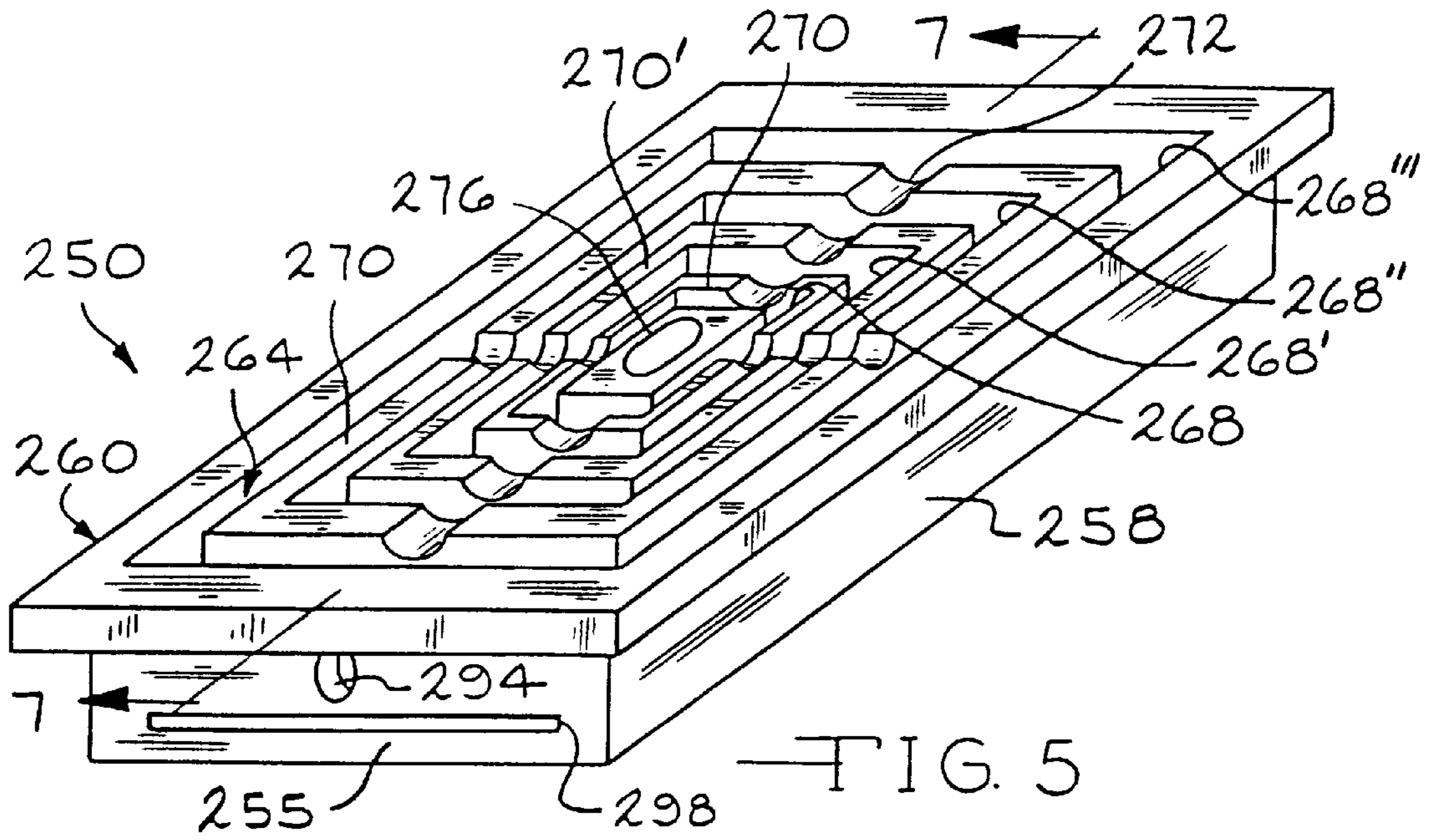


FIG. 4



PROCESS FOR PRODUCING THE MOLD INSERTS FOR INJECTION MOLDINGS

This application is a divisional Ser. No. 08/607,755, now U.S. Pat. No. 5,744,173, issued Apr. 28, 1998, filed on Feb. 27, 1996.

TECHNICAL BACKGROUND

The present invention relates to cast metal injection molding cavities and to a method of tool construction to make the cast metal cavities. The cast metal cavities are suitably durable for production requirements and also satisfy the dimensional and cosmetic standards that the molding industries require for most molded products.

BACKGROUND OF THE INVENTION

Manufacturing industries are intent on increasing their competitiveness by substantially reducing the time and cost of producing injection molding tools. However, it is important that any decreases in time and costs be achieved without sacrificing the quality and durability of the molding tools. With these competing goals in mind, various methods to produce economic and durable rapidly produced tools have been developed. One method relates to the use of reinforced polymer cavity and core inserts. However, when the inserts are exposed to high injection pressures there are often failures of the small surface features of the mold. Further, there is less than desirable heat dissipation through the polymer cavity and core wall sections into the cooling chambers adjacent the cavity and core sections.

Another method uses ion bombardment of a polymer cavity and core surfaces to enhance the surface durability of the cavity and core. This method has limited application, however, since only the areas of the cavity and core which are in a direct line of sight can be bombarded with the ions. In addition, these ion bombarded cavity and core inserts still have less than desirable durability performance.

Still another method uses molded cavity and core inserts which are made from high temperature thermoplastic or thermoset materials. However, these thermoplastic or thermoset inserts often experience unpredictable shrinkage and inadequate heat dissipation during the molding process.

Still another method uses a CNC-type cutting machinery which involves a great time and programming to generate a desired tool path to form the cavity and core inserts. Also, the cost to complete the milling of the inserts often renders such process uneconomical for many commercial uses.

Still another method involves a stereolithography-type approach (SLA) or laminated object manufacturing (LOM) which relies on the building, layer-by-layer, of a material to form the cavity and core inserts. However, the stereolithography produced molds have very limited life expectancy due to material weaknesses, bonding layer failures and the stresses which exist between each layer of material which forms the insert. In addition, there is often poor accuracy in the layering of the material and the resulting mold has an undesirable step or staircase effect on all angles of the mold.

Still another method involves casting of solid cavity and core inserts. However, there are many limitations on the overall sizes of inserts which can be cast. For instance, manufacturing limitations include the amount of molten material that can be transported and poured safely, at a proper rate, and without undesirably lowering the metal temperature. Further limitations on the use of solid cast cavity and core inserts relate to the difficulty in cooling the

solid cast inserts. In the past the solid cast inserts had been further subjected to a drilling process to provide a plurality of holes through the insert. A cooling fluid was pumped under pressure through these holes to cool the inserts. However, this isolated cooling system causes stresses in the product being molded due to the uneven cooling of the injection molded product. In addition, there is a tendency of the inserts to warp due to the cyclic fluctuations in the temperatures and the stresses on the inserts.

Accordingly, it is an object of the present invention to provide a casting process to make cavity and core inserts.

It is a further object of the present invention to provide a cast tool which reduces the expenses typically associated with conventional tool building by reducing the time and cost of producing inject molding tools with little sacrifice of the quality and durability of the tool.

It is a further object of the present invention to provide an apparatus useful in a casting process which will aid in producing highly accurate castings.

It is a further object of the present invention to provide cavity and core inserts which are adaptable to be used with standard molding equipment.

The present invention is most suitable for the manufacturing of injection molding cavity and core inserts. According to the present invention, it is now possible to produce cavity and core inserts that can greatly vary in size and complexity. The present invention also provides cast metal molding tools which comprise a core insert and a cavity insert. The cast metal inserts produced according to the process of the present invention are durable and meet most industry production requirements and satisfy most desired dimensional and cosmetic standards.

The present invention also provides an improved ceramic mold for use in forming the core and cavity inserts. The ceramic molds are especially suitable for producing smooth cast inserts of precise dimensions.

These and other objects and advantages of the present invention will be apparent from a reading of the following description of the invention and of the preferred embodiments.

SUMMARY OF THE INVENTION

The above and related objects of the present invention are obtained in a method which comprises, in part, forming ceramic molds which are used to form the cast metal shell cavity and core inserts. Another aspect of the present invention relates to the metal shell core insert and cavity insert which form a part of an injection molding tool.

In certain embodiments, when the desired end molded product has a relatively complicated shape, computer "solid" models of the end molded product are first generated and then from those computer models the cavity and core inserts are generated. The computer generated "solid" models of the cavity and core inserts are then used to form the actual three-dimensional cavity and core inserts.

It is to be understood, that in other embodiments, the ceramic mold can be directly made from a pattern without using computer generated models. However, for the sake of illustration herein, the use of computer generated models will be fully explained. The "solid" models are designed to have the shape of the metal shell cast cavity and core inserts.

In such embodiments, four patterns are required, two for the core insert and two for the cavity insert. The two core inserts comprise: one pattern of the face or front side of the core insert and one pattern of the back or shell side of the

core insert. The two cavity inserts comprise: one pattern of the face or front side of the cavity insert, and one pattern of the back or shell side of the cavity insert.

The four computer patterns of the cavity and core inserts are used to produce the patterns for the ceramic molds. In certain preferred embodiments, patterns for the ceramic molds are formed from wood, epoxy or plastic materials by using a stereolithography (SLA), CNC or other cutting equipment to produce the pattern for the ceramic mold.

It is to be understood that, when the various molds and patterns are produced, the patterns and molds are created with the necessary draft angles to allow the removal of the end product article from the mold. Model and pattern expansion is introduced to compensate for any shrinkage in the cast and mold operations which may occur.

After the ceramic mold is formed, it is removed without harm from the pattern. Thereafter, the geometry is reversed to create the cavity and core tools from the ceramic molds.

According to one embodiment of the present invention, the cavity and core inserts are each created to have open or shell areas on the back side of each insert. In one embodiment, the open or shell areas are formed during the casting of the inserts. In another embodiment, the back sides of the inserts are machined out after molding to produce the open areas in the cast cavity and core inserts.

In preferred embodiments, the working model or pattern can be made to represent the part or the reverse of the part (cavity and core pattern) depending on the complexity of the part desired and the tool production method to be used. It is further to be understood that according to the present invention, various methods or a combination of methods can be utilized to produce a working model. It is to be noted that the end product configuration surface and the various tolerance requirements will determine which methods or combination thereof are most appropriate for producing the end product.

It is to be understood that the working pattern used for making the ceramic pour-up mold can be made of various suitable materials which withstand the processing requirements of a ceramic pour-up. It is further to be understood that various ceramic material formulations are useful in providing a suitable ceramic mold. In one embodiment of the present invention (which is especially useful used in a cast iron process), the ceramic material formulation comprises ceramic materials and carbon fibers. The ceramic material formulation provides a ceramic mold having especially good tensile properties and a very desirable surface finish. The ceramic material formulation preferably comprises a relatively narrow range of sizes of ceramic aggregate material along with a predetermined amount of carbon fibers. The presence of the relatively narrow range of size of the aggregate material and the carbon fibers enhances the overall strength of the ceramic mold. The strength of a ceramic mold is needed especially during the demolding of the ceramic mold from the pattern into which the ceramic material has been poured. The ceramic material formulation does not adhere to the surface of the working pattern. The ceramic material formulation is especially useful, in certain embodiments, where the working pattern is formed of a rubber or epoxy or plastic material. Further, the ceramic material formulation is especially useful in producing a ceramic mold that has detailed, intricate and/or complex surface features. The resulting ceramic pattern has a superior final mold surface appearance.

The strength and density of the ceramic mold is improved over prior art ceramic molds. Carbon fibers are incorporated

into the ceramic formulation to provide additional strength. The incorporation of carbon fibers into the ceramic formulation allows for optimum performance during removal of the ceramic from the pattern. The viscosity and fill considerations of the ceramic material have been greatly improved by the use of this ceramic formulation. The lack of presence of large quantities of the large aggregate particles provides a ceramic mold having a more smooth or glossy surface, which surface allows the ceramic model to be readily removed from the pattern and provides a smooth surface for the casting of the cavity and core inserts.

In a most preferred embodiment, the carbon fibers are present in an amount in the ceramic formulation at about 0.01 to about 0.02%, by weight, and most preferably about 0.015%, by weight, and the carbon fibers most preferably have an average length of about $\frac{1}{4}$ to about $\frac{1}{16}$ inches and most preferably about $\frac{1}{8}$ inches.

The ceramic formulation of the present invention is stronger than conventional ceramic formulations. The increased strength reduces the possibility of damage or breakage which in turn allows the ceramic molds to be made having more complex cavity configurations than was previously possible.

In addition, the carbon fiber content also helps provide the surface of the ceramic mold with a much smoother surface than a conventional ceramic mold. The use of a smooth ceramic mold to cast the metal cavity and core inserts provides metal core and cavity inserts with smooth, less porous surfaces. The smoother, less porous surfaces of the cavity and core inserts allow for easier removal of the plastic molded end products from the inserts.

It has now been found that a suitable ceramic mold can be made without need for curing the ceramic when the ceramic is used in iron castings. In certain embodiments, for example, when the ceramic mold is used to form cast inserts made of iron, the ceramic mold can be subjected to ignition to burn off all but a minute amount of any alcohol or other volatile materials present in the ceramic material which have been entrapped in the "green" ceramic mold. However, in a further embodiment, such as where the ceramic mold is used to cast steel, it is within the contemplated scope of the claimed process herein that the ceramic mold be heated for a predetermined optimum time at a predetermined optimum temperature to completely cure the ceramic mold.

In another embodiment, it is contemplated that ceramic mold can be used to produce the face or front sides of the cavity and core inserts and that a sand-type casting method can be used to form the back or shell sides of the cavity and core inserts. In such embodiments, it has been found that the shelled out back-side of each metal cavity and core insert can be produced using, for example, a zircon-type sand with a binder solution formulation. One advantage of this embodiment is that the sand-type casting formulation provides an acceptably fast temperature dissipation rate during the molten metal pouring procedures to create each insert. Following this procedure, the extreme heat of the molten metal pour has an escape route in a direction through the somewhat porous sand area of the mold. The freshly casted metal insert thus cools and solidifies at the desired rate.

In especially preferred embodiments, it is desirable to produce zircon sand-type mold halves for the back sides of the inserts while the ceramic-carbon fiber composition is used to form the front sides of the inserts. That is, four mold halves are required, two front side ceramic molds and two back side sand-type molds.

To form the metal cavity and core inserts, a suitable molten metal material is poured into the ceramic or ceramic-

zircon/sand molds. The molten metal is heated to a desirable temperature (which varies according to each alloy), and the molten metal is fed into an area formed between the mold halves. After cooling, the sand mold and ceramic mold are removed from the metal insert. The time of cooling depends on the size and complexity of the mold being poured.

The final cast metal configuration comprises a cavity insert and a core insert. Each insert has a face or front side which defines the shape of one side of the end product being molded. Each insert also has a back or shell side which defines an open area or chamber. The back side of each insert also defines at least one, and preferably a plurality of support means such as pillars and/or support wall sections. The support pillars and/or wall sections provide strength to the insert. Also, as a cooling fluid flows or is moved through the open chamber, the flow of the fluid is disturbed as it passes around the support pillars and/or wall sections. This flow of fluid around the pillars and/or wall sections provides a quick and uniform cooling to the surface of the insert. It is to be understood that when the metal cavity and core inserts are formed, the metal cavity and core inserts include registration bosses and holes for alignment of the core inserts to the cavity inserts.

In certain embodiments, the core and cavity inserts are formed as a solid cast insert; i.e., there are no cooling chambers formed as a part of the back side of the insert during the casting process itself. In such embodiments, one final processing step includes grinding or milling of the back side of the cavity and core inserts, including providing the support pillars and/or wall sections to form the cooling chamber.

Thereafter, the metal mold is prepared for use by going through several final processing steps. It is to be understood that these final processing steps can be performed in any suitable order. The metal inserts are cleaned using a suitable procedure such as by sand blasting or a glass beading process.

Another processing step involves wherein the edges defining the back sides of the cavity and core inserts are machined or drilled to have various features such as O-ring grooves, a sprue pillar, side clamp slots, ejector pin holes, sprue seat, face side runner system and gates, side water hole connections and the like, which will be further described in detail below in connection with the Figures.

Another processing step can comprise wherein the front sides (or land areas) of the cavity and core inserts are milled or EDM (electron discharge machine) burned to create acceptable mating or parting line areas on the front side of each insert. The front sides of the cavity and core inserts are parallel to each other and are designed to be as close as possible to each other. This parallel relationship of the front sides allows the front sides of each insert to engagingly meet without any uneven areas. That is, a parting line of the mold is created by burning the cavity insert face to the core insert face and registering the flat rear areas of the inserts against the platens of an EDM machine. This creating of the parting provides acceptable "kiss-off" or parting line areas.

Other final processing steps include milling out any areas which may have excess warpage due the casting process and drilling the sides of the inserts to form waterline holes. Thereafter, a plurality of water connection hoses and the like are tapped into the water line holes. A flow of fluid is provided through the back sides of the cavity and core inserts, as will be described in detail below, to cool the inserts.

Another aspect of the present invention includes a molding apparatus for producing an end molded product. The

apparatus comprises the metal shell cavity and core inserts and further comprises a mounting plate attached to the cavity insert and a mounting plate attached to the core insert. The cavity mounting plate and core mounting plate each allow the cast cavity insert and core insert, respectively, to be mounted on a base cavity machine platen and a base core machine platen.

The use of the cavity mounting plate and core mounting plate allows the molded product manufacturer to have one molding apparatus that accepts more than one type or size of cavity insert (and cavity mounting plate) and more than one type or size of core insert (and core mounting plate). The present invention provides an apparatus with increased versatility by using different cavity and core inserts. That is, the cavity machine platen and core machine platen are configured to accept different cavity mounting plates and core mounting plates, respectively, as will be further described in detail below.

According to one embodiment of the present invention, the rear side of the cavity insert is ground or milled flat and parallel to the face surface of the cavity insert. An "O" ring groove is then milled into the rear side around that area intended to accept a sprue bushing. An additional groove is milled around the entire periphery of the rear side of the cavity insert. The grooved areas are then filled with a suitable leak deterrent material such as a silicone material. The cavity insert is then mounted and clamped to an "A" mold plate which having a sprue opening cut into it. The front side of the mold plate has been ground flat and parallel to the back side of the mold plate A. This results in a leak proof, hollow, sub assembly referred to as a "shell" or a "water jacket."

The rear side of the core insert is ground or milled flat and parallel to the face surface of the core insert. A groove is milled around the entire periphery of the rear side of the core insert. Additional grooves are milled into the rear side of the core insert around the areas that accept ejector pins. The ejector pins aid in removing the end molded product from the molding apparatus, as will be described in detail below. The grooved areas are then filled with a suitable leak deterrent material. The core insert is mounted to a "B" mold plate to form a "B" sub assembly. The "B" sub assembly is then drilled, through core insert and "B" mold plate, in the ejector pin location areas, preferably from the face side, for accurate ejector pin placement.

A further processing step comprises mounting both the "A" sub assembly and the "B" sub assembly into an electronic discharge machine (EDM), utilizing the flat and parallel rear sides of each "shell assembly," and burning the two faces together to form a parting line, or "kiss off" area on each casting for flash free plastic part manufacturing.

The "A" sub assembly is then mounted to a stationary platen of a molding press which matingly engages a sprue bushing. The "B" sub assembly is assembled to a suitable ejector box sub assembly, which has a predetermined number of the desired length and diameter ejector pins. The "B" sub assembly is held in place and in alignment with the ejector box. The entire "B" sub assembly with the ejector box sub assembly is then clamped to a movable platen of the molding press.

When a different end product is to be formed, a corresponding different cavity insert and mounting plate are operatively connected to the cavity machine platen and a different core insert and mounting plate are operatively connected to the core machine platen.

Another aspect of the present invention is that, in certain embodiments, the apparatus further comprises at least one,

and preferably a plurality of outside pressure bearing means which are present adjacent the core and cavity mounting plates, as will be discussed in detail below. During operation of the molding apparatus, the outside pressure bearing means act to absorb or bear the brunt of the pressure exerted against the core insert and the cavity insert. The presence of the pressure bearing means extends the useful life of the cavity and core inserts.

Once the insert/plate subassemblies are attached to the machine platens and/or ejector plates, a sprue bushing and a machine nozzle are operatively connected to the cavity machine platen. During operation of the molding apparatus, a suitable molding or plastic material is injected through the sprue bushing and into a molding or cavity area defined by the front sides of the cavity insert and the core insert.

In various embodiments, it is desirable to coat using, for example, a nickel-plating material or other type of suitable material to cover the entire surface of both the cavity and core inserts, front and back. In other embodiments, it is desirable to pressure seal each insert with a "radiator leak sealing" type of solution to eliminate any access to any porous areas in the cast inserts. In addition, if the nickel-plating is used, the nickel-plating adds a lubricating quality to the molding area defined by the front sides of the cavity and core inserts to allow for easier plastic part removal during the molding process.

The water lines are operatively connected to the cavity insert and the core insert. A water circulation system is connected to the cavity and core inserts to cool the inserts. In a preferred embodiment, the cooling water used in the water circulation system flows in parallel, as opposed to in series, in order to minimize mold face temperature fluctuations.

In preferred embodiments, use of a vacuum water circulation system prevents water leakage into the cavity area. A vacuum device is attached to the cavity and core insert connectors. The water circulation system pulls or draws water through the inserts as opposed to pushing or pressurizing the water into the inserts in order to avoid water leaks into the molding area.

By flood cooling the entire back sides or chambers of the inserts during the operation of the molding apparatus, an efficient cooling of the inserts is achieved. Further, the presence of support means allows the water flow to be agitated through the chambers on the back sides of the inserts to maximize the cooling capability and to avoid hot spots from forming in the inserts.

The present invention can be employed for casting any suitable type of metal such as, iron, steel, aluminum and the like.

The present invention provides a molding apparatus at a greatly reduced cost and at a greatly reduced time of preparation when compared with prior art systems. In particular, complex configurations can be effectively molded using the process of the present invention.

BRIEF OF THE FIGURES

FIG. 1 is a flow chart for a method of the present invention.

FIG. 2 is a schematic diagram showing a process for making a core insert and a cavity insert using ceramic molds and sand-type molds.

FIG. 3 is an exploded perspective view, partially in cross-section, of one embodiment of the present invention showing a portion of a molding apparatus comprising a cast metal shell core and cavity and mounting plates therefor.

FIG. 4 is a detailed view of a cavity insert and a core insert according to one embodiment of the present invention.

FIG. 5 is a perspective view of another embodiment of a cavity insert.

FIG. 6 is a top or plan view of the embodiment shown in FIG. 5.

FIG. 7 is a cross-sectional view taken along the line 7—7 in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, one embodiment of a method for forming cast metal core and cavity inserts is shown. It is to be understood that in various embodiments not all steps of this method are required and the various steps used are dependent upon the complexity of the mold being produced.

The method commences with the step 1 of preparing a model of the type of mold to be ultimately produced. This can be done using a CAD operation or other means as described above.

Step 2 involves converting the computer generated data into a three-dimensional object for example, using stereolithography modeling to produce a mold pattern. In step 2, a first model of the product to be formed is made.

Step 3 shows the model preparation wherein the model itself is made into a pattern. In step 3 a core insert pattern 10 and a cavity insert pattern 12 are made of a suitable material. The choice of material in the pattern allows a complex structure of the ultimate product to be formed. Also the choice of material must be able to withstand the temperatures of the ceramic formulation.

Step 4 involves the pouring of a ceramic formulation into and around the pattern. As described above, the ceramic formulation contains, in a preferred embodiment, generally uniform size ceramic aggregate materials and carbon fibers to allow the ceramic mold to have the desired smooth surface and strength, the result being a ceramic mold 20.

It is to be understood that, in certain embodiments, the various operational steps described herein are optional and that the method used to make the patterns for use in making the ceramic mold depend on the complexity of the part to ultimately be molded. Thus, in various embodiments it is not necessary to use the early steps of computer and/or stereolithography modeling. Rather, it is also within the contemplated scope of the present invention that a model of the article can be made itself. For molding a relatively uncomplex shape a suitable pattern can be made and the ceramic material can be poured into the pattern into without any earlier models being used. However, for the sake of illustration, the various steps which can be practiced in accordance with the present invention are described in detail herein.

Thereafter, in step 5 the ceramic molds 20 are used to receive a suitable molten metal 35 which then forms a metal core insert 40 and a metal cavity insert 50.

Referring now in particular to FIG. 2, a schematic illustration of one embodiment of the present invention is provided which shows the use of ceramic molds and sand molds, as described above. It should be understood however, that the embodiment shown in FIG. 2 can be also practiced using ceramic molds for both halves of the insert molds rather than the ceramic and sand molds as shown in FIG. 2. In FIG. 2, the working pattern 10 of the front side of the core insert 40 and the working pattern 12 of the front side of the

cavity insert **50** are formed of a suitable material. The ceramic formulation **15** is poured into the working pattern **10** to form a ceramic mold **20** for the core insert **40**. The ceramic formulation **15** is also poured into the working pattern **12** to form a ceramic mold **22** for the cavity insert **50**.

A sand-type mold **30** of the back side of the core insert **40** is formed and a sand-type mold **32** of the back side of the cavity insert **50** is formed, as described above.

The ceramic mold **20** of the front side of the core insert **40** and the sand type mold **30** of the backside of the core insert **40** are brought into mating engagement and a suitable molten metal material **35** is injected into the space between the ceramic mold **20** and the sand-type mold **30** to form the core insert **40**. Likewise, the ceramic mold **22** of the front side of the cavity insert **50** and the sand-type mold **32** of the back side of the cavity insert **50** are brought into mating engagement and a suitable molten metal material **35** is injected into the space between the ceramic mold **22** and the sand-type mold **32** to form the cavity insert **50**.

Referring again to FIG. 1, in step 6, the core insert **40** and the metal cavity insert **50** are further prepared for use such as by grinding and other preparations.

In step 7, the face surfaces of **40** and **50** are produced together to form an extremely close parting line or "kiss-off" area between the core insert **40** and the cavity insert **50**.

In step 8, the core insert **40** is operatively connected to a "B" side sub assembly **60** and the cavity insert **50** is mounted to an "A" side sub assembly **70**. The core "B" sub assembly **60** and the cavity "A" sub assembly **70** are then used to produce an end molded product **80** in a molding apparatus **90**, generally shown as Step 9.

Referring now to FIGS. 3 and 4, exploded perspective views of a portion of the molding apparatus **90** of the present invention are generally shown.

In FIG. 3, the core sub assembly **60** generally comprises a mold base **62** operatively connected to an ejector box **100**, which in turn is operatively connected to a core "B" mounting plate **110**. The sub assembly **60** is operatively connected to a movable machine platen **64**.

The ejector box **100** has at least one, and in most embodiments, a plurality of ejector pins **104** which extend through the "B" mounting plate **110**.

It is to be understood that various sizes of core mounting plates can be utilized and that the core inserts are interchangeable on the various size mounting plates. It is further to be understood that, for each different molding operation, various holes **106** are drilled through the core mounting plate **110** and matched with holes in the ejection box **100** such that the ejector pins **104** extend beyond an upper surface **112** of the core mounting plate **110**. O-ring grooves **119** are cut in the core mounting plate **110** adjacent the openings **106** which receive the ejector pins **104**. O-rings **122** are matingly received in the O-ring grooves **119** surrounding the openings **106** to prevent any leakage of fluid, as will be described in detail below.

Referring now to FIGS. 3 and 4, the core insert **40** is adjacent and operatively and sealingly connected to the upper surface **112** of the core plate **110**. The core insert **40** has a back or shell side **130** and a front side **140**. For ease of illustration the core insert **40** is shown in crosssection so that other features of the core insert **40** can be shown. However, it is to be understood that an O-ring **120** secures the back side **130** of the core insert **40** to the core mounting plate **110**. The back side **130** of the core insert **40** defines end walls **42** and **43** and side walls **44**. The walls **42**, **43** and **44**

define at least one interconnected opening or chamber **134** for receiving a cooling fluid. The back side **130** further defines at least one, and preferably a plurality, of support means **136** such as pillars which axially extend in a direction away from the front side **140**. The positions of the support pillars **136** are determined by the ultimate desired configuration of the final end product to be molded. Other considerations for the position of the support pillars **136** include providing agitation of the cooling fluid flow through the chamber **134** so that the core insert **40** is rapidly and evenly cooled. In the embodiment shown, each core pillar **136** defines an axially extending opening **138** for receiving the adjacent ejector pin **104**. However, it should be understood that in other embodiments that various of the support pillars **136** can have a solid configuration and are present for strengthening the core insert **40** and for providing agitation to the flow of cooling fluid through the chamber **134**.

In the embodiment shown, the front side **140** has a three-dimensional surface **142**. The surface **142** defines a portion of a cavity area **154** for receiving a plastic molding material (not shown). The surface **142** defines the shape of a side of the ultimate product to be molded.

The core insert **40** has openings **144** which extends through each of the opposing side walls **42** and **43** of the core insert **40**. (In the embodiment shown, the core insert **40** has a plurality of openings **144**. However, it is to be understood that in other embodiments the core insert **40** can have one opening **144**). The openings **144** are in communication with the chamber **134**. Although not shown, water or fluid connection valves and other coupling means are operatively connected to the openings **144**. Suitable fluid lines **146** are generally connected to the openings **144** and to a water or fluid circulator system **149**. In the embodiment shown, each side wall **42** and **43** has at least one slot **148** for clamping the core insert **40** to the mold apparatus **90**. In the embodiment shown, the slot **148** extends along an exterior surface of the walls **42** and/or **43**.

The cavity insert **50** is adjacent the front side **140** of the core insert **40**. The cavity insert **50** has a front side **150** which, in the embodiment shown, has a three-dimensional surface **152**. The surface **152** defines an opposing portion of the cavity area **154** which receives the plastic molding material.

The cavity insert **50** is operatively connected to the sub assembly **70** which comprises an "A" mounting plate **200** which is operatively connected to a mold base **240**. The sub assembly **70** is operatively connected to a machine platen **74**.

In operation, the front side **150** of the cavity insert **50** and the front side **140** of the core insert **40** matingly engage such that when the plastic material is being injected into the cavity area **154** there is no escaping of material from the cavity area **154**. The core insert **40** contains at least two registration areas **145** which each receive a registration pin **155** extending from the front side **150** of the cavity insert **50**. The registration areas **145** aid in aligning the cavity insert **50** to the core insert **40** during the cycling operation of the molding apparatus **90**.

The cavity insert **50** has a back or shell side **160** which generally defines end walls **52** and **53** and side walls **54**. The walls **52**, **53** and **54** define at least one interconnected opening or chamber **164** for a receiving cooling fluid. The back side **160** further defines at least one, and preferably, a plurality of support means **166** such as pillars. The back side **160** of the cavity insert **50** defines an O-ring receiving groove **170** for receiving an O-ring **180**. The cavity insert **50**

has at least one support means **167** which defines an axially extending opening **176** in communication with the cavity area **154**. The opening **176** receives the plastic material which is injected into the cavity area **154**. The opening **176** matingly engages a sprue bushing **190** for delivering the plastic material. It should be understood that for optimum operation in various embodiments it is desired to have an O-ring **182** adjacent the support means **167**.

In addition, in certain embodiments each cavity and/or core insert can have one or more additional support means such as walls or ribs **174** to provide additional support to the inserts **40** and/or **50**. For sake of clarity in the drawings, ribs are only shown in the cavity insert **50**; however, it should be understood that various support ribs can be present, if necessary or desired, in the cavity insert **50** and/or the core insert **40**.

The cavity insert **50** has openings **194** which extend through each of the side walls **52** and **53** of the cavity insert **50**. (In the embodiment shown, the cavity insert **50** has a plurality of openings **194**. However, it is to be understood that in other embodiments, the cavity insert **50** can have one opening **194**). The openings **194** are in communication with the chamber **164**. Although not shown, water or fluid connection valves and other coupling means are operatively connected to the openings **194**. Suitable fluid lines **196** are operatively connected to the openings **194** and to the fluid circulator system **149**. In the embodiment shown, each side wall **52** and **53** has at least one slot **198** for clamping the cavity insert **50** to the mold apparatus **90**. In the embodiment show, the slot **198** extends along an exterior surface of the walls **52** and **53**.

The back side **160** of the cavity insert **50** is matingly engaged to the cavity mounting plate **200**. The cavity mounting plate **200** defines at least one opening **204** for receiving the sprue bushing **190**. It is to be understood that various sizes of cavity mounting plates can be utilized. It is to be further understood that, for each different molding operation, the different cavity mounting plate can have the optimum placement of the opening **204** for receiving the sprue bushing **190**.

The cavity mounting plate **200** has an upper surface **206** which is adjacent the cavity mold base **240**. The cavity mold base **240** has an opening **244** which receives the sprue bushing **190**. The sprue bushing **190** is operatively connected to a machine nozzle **260** for injecting the suitable molten plastic material into the cavity area **154**. The cavity mold base **240** is operatively connected to the cavity machine platen **74**.

It is to be understood that the apparatus **90** can have a removable core mounting plate **110** and a removable cavity mounting plate **200**. Thus, according to the present invention, it is possible for the mold user to have available a fewer number of mounting plates which are useful with more than one cavity insert and more than one core insert. It is also now possible to have available relatively standard size cavity mounting plates and core mounting plates.

In certain embodiments of the present invention, the apparatus **90** further contains a plurality of pressure bearing means **220**. In a preferred embodiment, there are at least four pressure bearing means **220**, one positioned adjacent each corner of the core and cavity inserts **40** and **50**. The pressure bearing means **220** preferably have a height that is slightly longer or taller than the combined depth of the core insert **40** and the cavity insert **50** such that most of the molding pressure is absorbed by the pressure bearing means **220**. The pressure bearing means **220** allow the cavity mounting plate

200 and the core mounting plate **110** to be moved into mating engagement without putting excess pressure on the core insert **40** or the cavity insert **50**. Thus, in certain embodiments, with the presence of the pressure bearing means **220**, the core insert **40** and the cavity insert **50** are brought into facing engagement without undue stress or pressure put on the inserts **40** and **50**. In certain embodiments of the present invention, the presence of the pressure bearing means **220** extends the useful life of the inserts **40** and **50**.

It is to be understood that, in preferred embodiments, during the operation of the apparatus **90** the fluid circulator system **149** moves or pulls the fluid through the openings **194** and into the chamber **164** in the cavity insert **50** and through the openings **144** and into the chamber **134** in the core insert **40**. The rapid pulling movement of the fluid in a negative or vacuum manner allows rapid cooling of the inserts without the concern of having water fluid leaks into the cavity area **154** through various potential openings in the inserts. Further, the fluid is agitated by being pulled around the support pillars **136** and **166** and through the openings **134** and **164** to allow agitation and rapid cooling of the inserts **40** and **50**.

The core and cavity inserts of the present invention provide cavity area pressure resistance such that rapid cooling occurs with minimal risk of leakage. In addition, the present invention allows leak-free injector pin placement in the desired areas so that the end product is readily removed from the cavity area **154**. Further, there is a leak-free sprue bushing placement which is especially desirable so that no water or cooling fluid is allowed to migrate into undesirable areas. It is further understood that, in various embodiments, cooling fluid leakage occurring from chambers **134** and **164** into cavity area **154** is prevented by the chambers **134** and **164** being at a lower pressure than the cavity area **154**. Therefore, any leakage which occurs from less than accurate machining of inserts **40** and **50** results in air moving into the chambers **134** and **164** rather than fluid leaking into the cavity area **154**.

With the above-described mold casting apparatus and process, it is now possible to more efficiently mold injection molded parts. The temperature of the mold is efficiently regulated such that the mold can quickly produce the desired end product. The product being molded is subjected to more consistent cooling and is, therefore, less affected by stresses.

In operation, the sub assembly **60** comprising the ejector box **100**, the core mounting plate **110** and the core insert **40**, are moved along an axis toward and away from facing engagement with the cavity insert **50**. Plastic material is injected through the sprue bushing **190** into the cavity area **154** when the core insert **40** is in mating engagement with the cavity insert **50**. Simultaneously, fluid is pulled through the openings **144** and **194** into the chambers **134** and **164**, respectively, to cool the plastic material to below its temperature of crystallinity (T_c) such that the molded end product is produced. The pressure bearing means **220** allow the majority of the required clamp pressure to be transferred to the core mounting plate **110** and cavity mounting plate **200**. According to the present invention, it is possible to produce casting inserts **40** and **50** having thinner wall sections than previously used in other molding processes. The thinner walls of the inserts further allow for a rapid dissipation of heat and to satisfy processing parameters for the casting vendor.

The mounting plates **110** and **200** hold the cavity insert **50** and core insert **40**, respectively, in mating engagement

without subjecting the inserts **40** and **50** to undesirable stress or crack producing pressures. Upon completion of the molding process the subassembly **60** is moved in a direction away from the subassembly **70** and the ejector pins **104** push against the molded product to force the molded product from the mold.

Referring now to FIGS. **5-7** an alternative embodiment of a cavity insert **250** is shown. It is to be understood that a core insert (not shown) can have the same rear face configuration as will be described for the cavity insert **250**. The cavity insert **250** can be operatively connected to the subassembly **70** in a manner as described above. As seen in FIG. **7**, the cavity insert **250** has a front side **252** which defines a three-dimensional surface **254**. The surface **254** defines a portion of a cavity area similar to the cavity area **154** (shown in FIGS. **3** and **4**) for receiving a plastic molding material.

The cavity insert **250** has a back or shell side **260** which generally defines end walls **255** and **256** and side walls **258**. The walls **255**, **256** and **258** define at least one interconnected opening or chamber **264** for receiving a cooling fluid. In the embodiment shown, the chamber **264** defines a plurality of interconnected openings or channels **268** which are defined by support means **270**.

The cavity insert **250** has at least one center area or support pillar **277** which defines an axially extending opening **276** which is in communication with the cavity area **254**. The opening **276** receives the plastic material which is injected into the cavity area **254**. The opening **276** matingly engages a sprue bushing (not shown) for delivering the plastic material.

The back side **260** defines at least one support means **270** and preferably, a plurality of support means such as wall sections **270**. In the embodiment shown, the support means **270** comprises a plurality of wall sections (**270**, **270'**, **270''**) which axially extend from the front side **252** of the insert **250**. It is to be understood that the support means **270** can comprise a fewer or a greater number of wall sections than as shown in FIGS. **5-7**. However, for ease of illustration, the support means **270** shown herein has wall sections designated as **270**, **270'** and **270''**.

In the embodiment shown, the support wall sections **270** are symmetrically positioned in the chamber **264**. In certain embodiments, the thickness of each of the wall sections **270** is generally uniform for ease of manufacturing the insert. However, it is to be understood that the wall sections **270** can vary in thickness.

In certain embodiments it is desired that the distance between the wall sections **270** vary. As seen in FIGS. **5-7**, the distance between the first wall section **270** and the center area **277** is less than distance between the first wall section **270** and the second wall section **270'**. Correspondingly, the third wall section **270** is spaced apart from the second wall section **270'** at a distance greater than the distance between the second wall section **270'** and the first wall section **270**. That is, each of the channels **268'''**, **268''**, **268'** and **268** in the chamber **264** have a correspondingly wider width the farther removed each channel is from the center area **277** of the insert **250**.

The relatively closer distance between the wall sections **270** nearer the center area **277** provides support to the insert **250**. As the plastic material being inserted into the cavity area **254** there is more support where the plastic material is under the most pressure. The decreasing gap or width between the wall sections **270** allows the insert **250** to withstand higher injection pressures of plastic material being inserted into the cavity area **254**.

The support wall sections **270** define at least one water flow channel or opening **272** which allows fluid to flow from the one channel **268** on one side of a wall section **270** to another channel **268'** on the other side of the wall section **270**.

The cavity insert **250** has at least one opening **294** which extends through each of the side walls **255** and **256** of the cavity insert **250**. (In the embodiment shown, the cavity insert **250** has one opening **294**. However, it is to be understood that in other embodiments the cavity insert **250** can have a plurality of openings). The opening **294** is communication with the chamber **264**. Although not shown, water or fluid connection valves and other coupling means operatively connect the opening **294** to suitable fluid lines, such as those shown as **196** in FIGS. **3** and **4**, and to a fluid circulator system, similar to that shown as **149** in FIGS. **3** and **4**.

In the embodiment shown, each side wall **255** and **256** has at least one slot **298** for clamping the cavity insert to **50** to the mold apparatus. In the embodiment shown, the slot **298** extends along an exterior surface of the walls **255** and **256**.

Although not shown, it is to be understood that a core insert can have the same or similar rear side configuration as shown in FIGS. **5-7**. It is further to be understood that the embodiment for the cavity insert shown in FIGS. **5-7** is especially useful in high pressure molding operations where the cavity insert and/or core insert are subjected to extreme high pressures.

While the invention has been described in terms of various preferred embodiments, the skilled artisan will appreciate the various modifications and substitutions, omissions and changes which may be made without departing from the spirit thereof. Accordingly, it is intended that the scope of the present invention be defined solely by the scope of the following claims including the equivalents thereof.

I claim:

1. A method for producing a molding apparatus comprising
 - a core insert (**40**) removably attached to a first, core mounting plate (**110**), the core insert (**40**) having a back side (**130**) and a front side (**140**), the back side (**130**) defining a chamber (**134**) for receiving a cooling fluid, the back side (**130**) having at least one support means (**136**) axially extending in a direction away from the front side (**140**), and
 - a cavity insert (**50, 250**) removably attached to a second, cavity mounting plate (**200**), the cavity insert (**50, 250**) having a back side (**170, 260**) and a front side (**160, 252**), the back side (**170, 260**) of the cavity insert (**50, 250**) defining a chamber (**164, 264**) for receiving a cooling fluid, the back side (**170, 260**) of the cavity insert (**50, 250**) having at least one support means (**166, 270**) axially extending in a direction away from the front side (**160, 252**) of the cavity insert (**50, 250**), the front side (**140**) of the core insert (**40**) and the front side (**160, 252**) of the cavity insert (**50, 250**) defining a cavity (**154**) for molding an article;
 - at least one means (**149**) for circulating a fluid through the chambers (**134** and **154**) of the core insert (**40**) and cavity insert (**50, 250**); and,
 - at least one pressure bearing means (**220**) adjacent the core (**40**) and cavity (**50, 250**) inserts, the pressure bearing means (**220**) having a height that is longer than the combined height of the core insert (**40**) and the cavity insert (**50**), the pressure bearing means (**220**) substantially absorbing the molding pressure when the

core insert (40) and cavity insert (50, 250) are brought into facing engagement under molding pressure during operation of the molding apparatus (90), the pressure bearing means substantially transfers the molding pressure from the core insert (40) and the cavity insert (50, 250) to the core mounting plate (110) and the cavity mounting plate (200), respectively, during operation of the molding apparatus (90), the method comprising:

forming a first, ceramic mold (20) to form the front side (140) of the core insert (40);

forming a second mold (30) to form the back side (130) of the core insert (40);

forming a third, ceramic mold (22) to form the front side (160, 252) of the cavity insert (50);

forming a fourth mold (32) to form the back side (170, 260) of the cavity insert (50);

placing the first, ceramic mold (20) and the second mold (30) into mating engagement and injecting a first quantity of a suitable metal material (35) therebetween to form the core insert (40); and

placing the third, ceramic mold (22) and the fourth mold (32) into mating engagement and injecting a second quantity of the suitable metal material (35) therebetween to form the cavity insert (50).

2. A method of claim 1 wherein at least one of the second mold (30) and/or fourth mold (32) comprises a sand type mold.

3. The method of claim 1 wherein at least one of the second mold (30) and/or fourth mold (32) comprises a ceramic mold.

4. The method of claim 1 further comprising the step of curing the ceramic molds by heating the ceramic molds at a sufficient temperature for a sufficient time to cure the ceramic molds.

5. The method of claim 3 further comprising the step of curing the ceramic molds by heating the ceramic molds at a sufficient temperature for a sufficient time to cure the ceramic molds.

6. The method of claim 1, wherein at least one of the cavity insert (50) and the core insert (40) includes walls defining said respective chamber (134 or 164, 264) and contains one or more support ribs (174) extending from said respective walls (42, 43, 44; 52, 53, 54).

7. The method of claim 1 wherein the cavity insert (50) and core insert (40) have substantially smooth or glossy surfaces, the cavity insert and the core insert each being formed using the ceramic molds having a formulation comprising ceramic particles and carbon fibers.

8. The method of claim 7, wherein the carbon fibers are present in the ceramic formulation at about 0.01 to about 0.02%, by weight, and have an average length of about $\frac{1}{4}$ to about $\frac{1}{16}$ inches.

9. The method of claim 8, wherein the carbon fibers are present in about 0.015%, by weight, and the carbon fibers have an average length of about $\frac{1}{8}$ inches.

10. The method of claim 1, wherein the support means (136) of the core insert (40) comprises a plurality of pillars (136) which axially extend from the back side (130) of the core insert (40).

11. The method of claim 1, wherein the support means (166) of the cavity insert (50) comprise a plurality of pillars (166) which axially extend from the back side (170) of the cavity insert (50).

12. The method of claim 1, wherein the support means (270) of the cavity insert (250) comprises a plurality of wall sections (270) which axially extend from the back side (260) of the cavity insert (250).

13. The method of claim 1, wherein the support means (270) of the cavity insert (250) comprises a first wall section (270) which is spaced apart at a first predetermined distance from an adjacent, second wall section (270').

14. The method of claim 13, wherein the second wall section (270') is spaced apart at a second predetermined distance from an adjacent third wall section (270'') wherein the second predetermined distance is greater than the first predetermined distance.

15. The method of claim 1, wherein the support means of the core insert comprises a plurality of wall sections which axially extend from the back side of the core insert.

16. The method of claim 15, wherein support means of the core insert comprises a first wall section which is spaced apart at a first predetermined distance from an adjacent, second wall section.

17. The method of claim 16, wherein the second wall section is spaced apart at a second predetermined distance from an adjacent third wall section wherein the second predetermined distance is greater than the first predetermined distance.

18. The method of claim 12, wherein at least one said wall section (270) defines a channel (272) for allowing fluid to flow into the chamber (264) of the cavity insert (250).

19. The method of claim 15, wherein at least one said wall section defines a channel for allowing fluid to flow into the chamber (134) of the core insert (40).

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,944,087
DATED : August 31, 1999
INVENTOR(S) : Robert A. Sterett

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 14, line 64, please delete "beating" and insert --bearing--.

Signed and Sealed this
Thirtieth Day of May, 2000

Attest:



Q. TODD DICKINSON

Attesting Officer

Director of Patents and Trademarks